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Alternatives to Heavily-Weighted Final Exams in Engineering Courses

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Summary
In many engineering courses, cumulative final exams typically comprise the largest component of a student's grade. However, from a learner's perspective, final exams are frequently associated with high levels of stress, which may hinder student performance during the exam period. In this interactive engineering-focused workshop, I will discuss the challenges associated with final exams that are heavily- weighted and propose alternative forms of summative assessment of student learning. Through a demonstration of a survey conducted in a Civil Engineering class at the University of Waterloo, I will demonstrate students' perspectives on final exams. Furthermore, using data from twenty-one engineering course outlines from the Massachusetts Institute of Technology (MIT), I will demonstrate common assessment approaches used in engineering courses. The workshop will conclude by asking participants to share ideas for alternatives to heavily-weighted final exams and will introduce some alternative methods of assessment that have been suggested in education literature.

Keywords
Assessment, final exams, assessment strategies, engineering education

Cover Page Footnote
I would like to sincerely thank Dr. Svitlana Taraban-Gordon from the Centre for Teaching Excellence at the University of Waterloo for her continuous and helpful support throughout this project and the Civil and Environmental Engineering students of CIVE 486 in Fall 2012 term participated voluntarily in the related survey. I also appreciate the comments from the reviewers and the TIPS editorial team who helped to improve this work.

Alternatives to Heavily-Weighted Final Exams in Engineering Courses

Amin Haghnegahdar, University of Waterloo

SUMMARY

In many engineering courses, cumulative final exams typically comprise the largest component of a student's grade. However, from a learner's perspective, final exams are frequently associated with high levels of stress, which may hinder student performance during the exam period. In this interactive engineering-focused workshop, I will discuss the challenges associated with final exams that are heavily-weighted and propose alternative forms of summative assessment of student learning. Through a demonstration of a survey conducted in a Civil Engineering class at the University of Waterloo, I will demonstrate students' perspectives on final exams. Furthermore, using data from twenty-one engineering course outlines from the Massachusetts Institute of Technology (MIT), I will demonstrate common assessment approaches used in engineering courses. The workshop will conclude by asking participants to share ideas for alternatives to heavily-weighted final exams and will introduce some alternative methods of assessment that have been suggested in education literature.

KEYWORDS**:** Assessment, final exams, assessment strategies, engineering education

LEARNING OBJECTIVES

By the end of this workshop, participants will be able to:

- discuss limitations of heavily-weighted final exams in the engineering context; and
- identify one or two alternative methods of assessment to the heavily-weighted final exam that is amenable to an instructional context

REFERENCE SUMMARIES

Gregerson, A. & Franey, S. (2012). Optional final exams as an assessment tool in Engineering curricula. *119th ASEE Annual Conference and Exposition*, *San Antonio, TX, June 2012.*

In this paper, Gregerson and Franey (2012) question the traditional assessment method of heavily-weighted final exams and propose an optional final exam as a possible alternative. They argue that an optional final helps overcome the high stress and heavy workload that students experience during the final exam period and will improve the quality of assessment. Gregerson and Franey examine case studies and surveys of two different Electrical & Computer Engineering courses at the University of Wisconsin, Madison, which indicate that more than 80% of the students supported this approach. This workshop uses this article to discuss the positive and negative implications of the final exam and presents the optional final exam as one of the alternative strategies.

Le, K. N., Tam, V. W. Y. & Tam, L. (2009). Assessment schemes in engineering courses using spectral techniques. *International Journal of Engineering Education 25(3): 547-556.*

Le et al. (2009) compare eight different assessment models (seminars, open-book mid-semester tests, closed-book mid-semester tests, problem-based assignments, presentations,

multiple-choice questions, closed-book finals and open-book finals) to determine students' attitude and understanding in engineering undergraduate and postgraduate courses at Griffith University, Australia. Le et al. (2009) find that the seminar, presentation and problem-based assignment are the most effective assessment approaches from the students' perspective. Consequently, the authors recommend using a variety of assessments and a balanced weighting scheme. This workshop uses this article to present general suggestions for alternative assessment strategies.

Mezeske, R.J. & Mezeske, B.A. (2007). *Beyond tests and quizzes: Creative assessments in the college classroom*. San Francisco, CA: Jossey-Bass.

Mezeske and Mezeske (2007) define basic concepts such as "assessment" in order to demonstrate the characteristics of a good assessment. In so doing, Mezeske and Mezeske (2007) suggest alternate methods of assessment that move beyond the standard format of tests. This book also discusses how to be creative in developing student assessment techniques and the importance of using a variety of assessment techniques in the classroom. In the workshop, this book helps to provide an overview of student assessment and its importance in student learning.

Brown, S. & Glasner, A. (1999). *Assessment Matters in Higher Education: Choosing and Using Diverse Approaches*. Buckingham, UK: SRHE and Open University Press.

This source emphasizes the importance of the assessment in Higher Education, highlights some of the failures of the traditional written tests and provides advice on conducting effective assessments. This workshop uses this book to discuss importance of assessment and some of the disadvantages of the traditional unseen written exams.

Wankat, P. C. & Oreovicz, F. S. (1990). Teaching engineering. Purdue University. Retrieved November 16, 2012, from https://engineering.purdue.edu/ChE/AboutUs/Publications/TeachingEng/index.html

Wankat and Oreovicz (1990) provide a comprehensive overview of different assessment techniques in engineering. In chapter 11, Wankat and Oreovicz (1990) discuss how to use test in engineering courses and the respective advantages and disadvantages of final exams. They suggest having more equally weighted exams during the term may serve as a possible replacement to one heavily-weighted final exam. This workshop uses this book to highlight the advantages and disadvantages of final exams and to introduce alternative assessment strategies.

Gibbs G., Habeshaw, S. & Habeshaw, T. (1986). *53 interesting ways to assess your students.* Bristol, UK: Technical and Educational Services.

Gibbs et al. (1986) provide many alternative assessment methods that can be adopted by different disciplines according to the respective learning objectives of the course. This

workshop uses this resource to provide a list of alternatives to the traditional closed book final exam.

CONTENT AND ORGANIZATION

The workshop can be between 60 to 90 minutes depending on the number of participants, their educational background and the amount of activities and interaction. Below is a suggested outline and timetable for conducting a 90-minute workshop.

Duration (min)	Subject	Activity	Purpose
10	Ice Breaker	Divide participants into small groups or pairs and ask them to consider the following questions: • What is your experience with heavily-weighted exams as a student? • Is this different from your experience as an instructor? Have groups introduce themselves and present their experience to the larger class.	Introduce the participants to each other and provide an introduction to the content of the workshop.
20	Background	This component comprises of four sections. 1. Introduce and define the notion of "assessment". Potential working definitions include: • "Any process that appraise an individual's knowledge, understanding, abilities or skills" (UK QAA, 2006, p.4) • "Classroom assessment is an approach designed to help teachers find out what students are learning in the classroom and how well they are learning it. This approach is learner centered, teacher directed, mutually beneficial, context specific, ongoing and firmly rooted in good practice" (Angelo & Cross, 1993, p.4, cited in Mezeske & Mezeske, 2007, p.3)	Familiarize participants with the definition of assessment and its importance and applicability outside of higher education. By differentiating between formative and summative assessment methods, this section will encourage participants to reflect on the different methods of student assessment.

2. Emphasize the importance of assessment. Remind participants that, **"Students can escape bad teaching: they can't avoid bad assessment"** (David Boud, 1994, cited in Brown 1999, p.4). Furthermore, assessment is:
   - Valued by students, teachers, institutions, employers and parents;
   - Has a profound role in facilitating learning; and
   - A central component of higher education.

3. Provide an overview of formative and summative assessment types. Ask participants how many are familiar with "formative and summative" assessment techniques. Use the following table as a guide to help facilitate this discussion.

	Formative	**Summative**
Feedback	Comments but no grades	Grades and comments
Timing	Occurs during class or a learning experience	Occurs at the end of a unit or course
Rationale	Promotes learning	Gauges achievement
Example	Class activities such as question and answer periods	Assessment techniques such as final exams

4. Ask participants to help generate a list of different assessment methods. If time permits, ask participants to categorize these assessment methods according to whether or not they are formative or summative.

<table>
<tr>
<td>20</td>
<td>Pros and Cons of Final Exams</td>
<td>Conduct a brief presentation on the tradition of hefty two- or three-hr cumulative final exams in science, technology, engineering and math (STEM) courses. If possible, include examples of sample assessment strategies.

Ask participants to brainstorm some advantages and disadvantages of final exams. The following table is an example of the type of responses participants may generate.

<table>
<tr><th>Advantages</th></tr>
<tr><td>• Measures overall individual comprehension
• Comparatively easy to design and grade
• Students are familiar with final exams
• Favors slow learners
• Can help promote learning</td></tr>
</table>

<table>
<tr><th>Disadvantages</th></tr>
<tr><td>• Many students dislike this format
• Does not promote deep learning
• This type of assessment is often unrelated to job-specific skills
• Can promote health-related issues involving stress, particularly during the final exam period</td></tr>
</table>

Conclude this section by providing data from a recent survey of forty-three near-graduation students in Civil and Environmental Engineering at the University of Waterloo. This survey indicates that fourth year students continue to find final exams to be stressful, especially when they comprise a large percentage of the final mark, often ranging from 50-70%. This stress often results in a lower performance.

Consult Appendix B for more details on</td>
<td>Encourage participants to consider alternative assessment methods to the traditional cumulative final exam.</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td>this study.</td><td></td></tr>
<tr><td>30</td><td>Alternative Assessment Strategies</td><td>Conduct a small group discussion with participants. Ask them to reflect on courses they have either previously taken or previously taught and complete the following two tasks:
• Develop one or two alternative assessment techniques in lieu of heavily-weighted final exams.
• Describe their rationale for choosing these strategies.

Conduct a brief lecture on common assessment strategies used by the Massachusetts Institute of Technology using the following histogram.

<table>
<tr><th>MIT</th><th>Final Exam</th><th>Mid-Term/Quiz</th><th>Assignments</th></tr>
<tr><td>%</td><td>%</td><td>%</td><td>%</td></tr>
<tr><td>0</td><td>38</td><td>5</td><td>5</td></tr>
<tr><td>5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>10</td><td>0</td><td>0</td><td>10</td></tr>
<tr><td>15</td><td>5</td><td>5</td><td>0</td></tr>
<tr><td>20</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>25</td><td>14</td><td>14</td><td>24</td></tr>
<tr><td>30</td><td>19</td><td>10</td><td>5</td></tr>
<tr><td>35</td><td>14</td><td>10</td><td>24</td></tr>
<tr><td>40</td><td>0</td><td>14</td><td>10</td></tr>
<tr><td>45</td><td>0</td><td>5</td><td>0</td></tr>
<tr><td>50</td><td>0</td><td>10</td><td>14</td></tr>
<tr><td>55</td><td>0</td><td>5</td><td>0</td></tr>
<tr><td>60</td><td>0</td><td>10</td><td>0</td></tr>
<tr><td>65</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>70</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>75</td><td>0</td><td>5</td><td>0</td></tr>
<tr><td>80</td><td>0</td><td>0</td><td>0</td></tr>
</table>
<table>
<tr><td>Min</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Max</td><td>35</td><td>75</td><td>50</td></tr>
<tr><td>Median</td><td>20</td><td>35</td><td>30</td></tr>
<tr><td>Average</td><td>17</td><td>37</td><td>30</td></tr>
</table>
* The 21 MIT courses included in this histogram include 13 Civil and Environmental Engineering Classes, 3 Mechanical Engineering Classes, 2 Biological Engineering Classes, 1 Material Engineering Class, 1 Architecture Class and 1 System Design Class. See Appendix C for more information.

Explaining the following facts about this histogram:
• Of 21 undergraduate engineering</td><td>Promote the idea that alternate assessment techniques have several advantages over traditional methods of assessment.

Encourage participants to consider how they might implement these alternative strategies in their own classes.</td></tr>
</table>

courses (primarily in the Department of Civil and Environmental Engineering)*, final exams comprise between 0-35% of the final grade.
- Nearly 40% of courses at MIT do not have a final exam.
- As a common practice, MIT relies more on team-based assignments and class participation than cumulative final exams.

To further support the above findings, provide students with a sample course assessment breakdown from MIT and show them the corresponding video of the instructors explaining their rationale behind their assessment approach in this course.

Introduction to Computers and Engineering Problem Solving (1.00 / 1.001, Fall 2005)
Problem Sets (10): 48% In-Class Quizzes (2): 20% Final Exam: 22% Weekly Tutorials (Participation): 5% Active Learning (Attendance): 5% Total: 100%

Consequently show students the following corresponding video, accessible at the following URL: http://www.youtube.com/watch?v=FccfP6Em-3o
Note: This video is about 6 minutes and should be watched in its entirely for maximum educational benefit. The main points relevant for this workshop focus on assessment strategies, which occurs between 2'45" to 3'20" of the video.

Conclude lecture by offering a summary of literature that supports the conclusion that alternative assessment techniques are preferable to cumulative final exams

		because they promote deeper learning and are less stressful. Sample research summaries to cite include the following sources:
		
		• Wankat & Oreovicz (1990):
		  • A higher frequency of tests reduces the weight and stress per test
		  • Assignments should have a maximum weight of 10-15%
		
		• Gregerson & Franey (2012):
		  • Optional final exam are useful when course materials have been previously tested
		
		• Gibbs et al. (1986):
		  • Different format in lieu of a traditional unseen final exam include:
		  o A seen exam, in which students are shown the exam or a pool of questions in advance.
		  o A take-home exam, in which students have a specified set of time to complete the exam.
		  o Revealed exam questions, in which students receive previously-administered exam
		  o An open-book exam, in which students are allowed to bring course materials and/or a "cheat" sheet to the exam	

5	General Suggestions	Give participants a list of general suggestions for improving the range and diversity of assessment techniques in their classrooms. This may include: • A mixture of formative and summative assessments • A variety of assessment methods that targets different learning styles • Assessments that encourage deep	Summarize the workshop into a series of best practices that participants can use in developing their own assessment strategies.

		learning To develop these types of assessment techniques, it is helpful to consider: • Extracurricular goals; and • Innovation and creativity	
5	Conclusion and Summary	Conclude by summarizing the key points of the workshop: • Traditional cumulative exams are neither the only nor the best way to assess achievement in engineering courses; • It is possible to implement alternative strategies, such as offering a higher frequency of less weighted tests; and • It is important to be creative and think beyond written tests.	Encourage students to adopt a variety of assessment techniques to supplement or replace traditional assessment methods.
Total Time: 90 minutes			

PRESESENTATION STRATEGIES

This workshop is very interactive and encourages participants to reflect upon their own experiences with final exams. Although the workshop encourages audience participation, there are also several opportunities for individual reflection. These activities can be modified or changed based on the workshop facilitator's discretion according to the time available, the number of participants and the participants' background and familiarity with alternative assessment techniques.

ADDITIONAL REFERENCES

Angelo, T.A. & Cross, K.P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). San Francisco, CA: Jossey-Bass.

Boud, D. (1994). Keynote speech at SEDA Conference on Assessment, Telford, May 1994.

Brown, S. (1999). Institutional strategies for assessment. In S. Brown & A. Glasner (Eds), *Assessment Matters in Higher Education: Choosing and Using Diverse Approaches* (pp.3-13). Buckingham, UK: SRHE and Open University Press.

Mezeske R.J. & Mezeske B.A. (2007). Why creative assessment? In R.J. Mezeske & B.A. Mezeske (Eds), *Beyond tests and quizzes: Creative assessments in the college classroom* (pp. 1-7). San Francisco, CA: Jossey-Bass.

Quality Assurance Agency (2006). *Code of practice for the assurance of academic quality and standards in higher education: Section 6: Assessment of students.* Retrieved June 13, 2013, from

http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/COP_AOS.pdf

Race Ph. (1999). Why Assess Innovatively? In S. Brown & A. Glasner (Eds), *Assessment Matters in Higher Education: Choosing and Using Diverse Approaches* (pp.57-70). Buckingham, UK: SRHE and Open University Press.

APPENDIX A: Handout

This handout may be distributed to the audience at the beginning of the workshop so participants can fill in additional information as the workshop progresses.

Alternatives to Heavily-Weighted Final Exams in Engineering Courses

By: _____ Date: _____

LEARNING OBJECTIVES
By the end of this workshop, participants will be able to:

- Discuss limitations of heavily-weighted final exams in the engineering context; and
- Identify one or two alternative methods of assessment to the heavily-weighted final exam that is amenable to an instructional context

DEFINTION OF ASSESSMENT

- "Classroom assessment is an approach designed to help teachers find out what students are learning in the classroom and how well they are learning it. This approach is learner centered, teacher directed, mutually beneficial, context specific, ongoing and firmly rooted in good practice" (Angelo & Cross, 1993, p.4, cited in Mezeske & Mezeske, 2007, p.3)

IMPORTANCE OF ASSESSMENT

- Remind participants that while "[s]tudents can escape bad teaching: they can't avoid bad assessment" (David Boud, 1994, cited in Brown 1999, p.4).

	Formative	**Summative**
Feedback		
Timing		
Rationale		
Example		

FINAL EXAMS

Advantages	**Disadvantages**

ALTERNATIVE ASSESSMENT STRATEGIES

-
-
-
-
-

SUMMARY AND CONCLUSION

-
-
-
-
-

APPENDIX B: Civil Engineering Student Survey at the University of Waterloo

In October 2013, I conducted a survey of fourth-year Civil and Environmental Engineering students from Hydrology (CIVE 486) at the University of Waterloo for the purpose of this workshop. Forty-three students with an anticipated graduation date of April 2013 participated voluntarily in this survey. Below is a transcription of the survey.

1- I feel stressed during final exams in general

Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

2- Often times, final exams constitute a large portion of my grade in a course

Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

3- I feel more stressed when final exams constitute a large portion of my grade

Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

4- I feel more stressed during the final exams period

Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

5- I feel overwhelmed during the final exams period

Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

6- I am likely to perform worse when facing stress/heavy workload during the final exam period

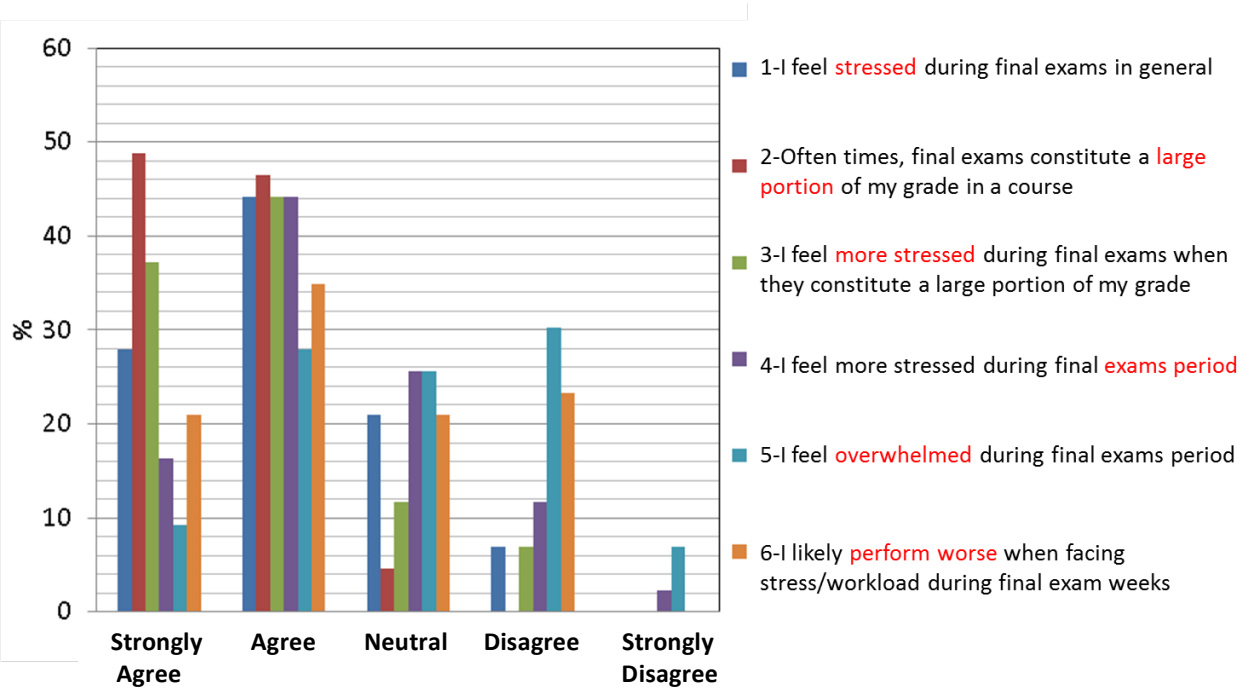
Strongly Agree Agree Neutral Disagree Strongly Disagree

Comment:

Choose your preferred method of assessment from the list below (feel free to comment):

a. More exams with lower and equal weights each
b. One heavily-weighted exam
c. An optional final exam
d. Other (please specify)

The results of the survey are as follows:



APPENDIX C: Sample MIT Course Outlines

I considered 21 engineering courses from MIT, primarily from the Department of Civil & Environmental Engineering. These courses can be readily accessed under the Civil and Environmental Engineering link via the MIT *OpenCourseWare* website, http://ocw.mit.edu/index.htm, which provides free access to many MIT course outlines (accessed during October-November 2012). The courses used for the study cited in this workshop are listed below. More information is available through the author upon request.

Row	Course Number & Name	Term
1	Introduction to Computers and Engineering Problem Solving (1.00 / 1.001)	S2005
2	Introduction to Computers and Engineering Problem Solving (1.00 / 1.001)	F2005
3	Uncertainty in Engineering (1.010)	F2008
4	Project Evaluation (1.011)	S2011
5	Computing and Data Analysis for Environmental Applications (1.017 / 1.010)	F2003
6	Ecology I: The Earth System (1.018J / 7.30J)	F2009
7	Ecology II: Engineering for Sustainability (1.020)	S2008
8	Project Management (1.040 / 1.401J)	S2004
9	Engineering Mechanics I (1.050)	F2007
10	Solid Mechanics (1.050)	F2004
11	Mechanics and Design of Concrete Structures (1.054 / 1.541)	S2004
12	Engineering Mechanics II (1.060)	S2006
13	Transport Processes in the Environment (1.061 / 1.61)	F2008
14	Introduction to Modeling and Simulation (3.021J / 1.021J / 10.333J / 18.361J / 22.00J) (in Material science & Eng.)	S2011
15	Frameworks and Models in Engineering Systems / Engineering System Design (ESD.04J / 1.041J / ESD.01J) (in Engineering Systems Division)	S2007
16	Fundamentals of Energy in Buildings (4.42J / 1.044J / 2.45J) (in Architecture)	F2010
17	Dynamics and Control I (2.003J / 1.053J) (in Mechanical Engineering)	S2007
18	Dynamics and Control I (2.003J / 1.053J) (in Mechanical Engineering)	F2007

19	Dynamics and Vibration (13.013J) (in Mechanical Engineering)	F2002
20	Chemicals in the Environment: Toxicology and Public Health (BE.104J) (in Biological Eng.)	S2005
21	Systems Microbiology (20.106J / 1.084J) (in Biological Eng.)	F2006